



Field Hospital in Disasters: A Systematic Review

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Abstract

Background: Field hospitals (FH) can be mobile or fixed. The main goal of FHs is providing health care and preventing injuries caused by disasters or providing emergency medical operations. However, preparing a safe and fast-erupting structure and facility is very important.

Objectives: In this systematic review study, field hospitals are reviewed.

Methods: In the present study, a systematic review was performed following the PRISMA guideline. To identify the articles, MEDLINE, web of science, Google scholar, PubMed, Persian journals and databases were searched to find related papers.

Results: After full text screening as the final screening step, 20 papers were entered in the study. Findings showed that structures used for establishing a FH are usually tents, using vehicles (trucks and buses), pre-fabricated steel, and concrete structures. The FHs were used for war and earthquake disasters. Conex, tent, steel, and concrete structure are the most used structures for FH in wars, while tents are the most common structure used for natural disasters.

Conclusions: The present study reviewed available reports on FH to collect useful data that should be focused on establishment of an FH suitable for a disaster. Furthermore, this study provides a list of the most important indexes that must be considered in proposing a type of FH. Tent structure was the most common structure for the establishment of FHs.

Keywords: Hospitals, Disaster Preparedness, Earthquakes, Emergency Response, War

1. Background

When natural disasters, such as flood, earthquake or man-made disasters (terrorist and war attack) occur, the importance of medical facilities is the most considerable (1). As data from the emergency events database (EM-DAT) of the centre for research on the epidemiology of disasters show, the global disaster rate is increasing (2). As EM-DAT illustrates, during the period of 1970 to 2008, developing countries had more than 95% deaths related to natural disasters. In addition, it can be concluded the disaster occurrence became more frequent, severe and destructive in the recent years, especially in developing countries (2, 3). When a disaster occurs it causes serious damage in health care services and leads to emergency health care needs. In case of Iran, as a one of the countries categorized as a developing country, the climate, geography, and geology make it one of the world's top ten disaster-prone countries in terms of the frequency of unexpected events (2). Approximately, more than 31 types of natural disasters have been

recorded in the history of this country. Furthermore, the Iran-Iraq War that was an armed conflict and took eight years (from 1980 to 1988) shows that unnatural disasters are probable to take place, as well. Therefore, health care systems and the establishment of FHs have a significant effect in decreasing the effects of these disasters and saving injuries. Establishing of FHs in these circumstances to save injuries is an essential task. As soon as FH is established, a larger number of people would be saved thus there is a need to know suitable structure at each disaster or geographical location by management teams. If a disaster strikes a country, all political, economic and cultural infrastructures are threatened. However, all equipment and facilities must be mobilized to respond to the crisis (1). Furthermore, FHs are health care units with mobile or fix structures. These medical care units are used to save lives after striking of a crisis to a community or to temporarily take care of casualties on-site before they can be safely transported to more permanent hospital facilities (4). The

term FH mostly refers to military situations, yet it can be used in natural disasters. The concept of FHs was born in World War II and the first surgical hospitals were brought to the frontline by Baron Dominique Jean Larrey, who was called the father of combat medicine (5). These types of hospitals consist of three or four smaller units, which are generally situated near the battlefield (6). Military FH is called mobile army surgical hospital (MASH) and was the first temporary medical unit to save soldiers in wars, such as Korea and Vietnam wars (5). Today, there are many kinds of medical care units with various structure and facilities that are used in wars as well as in other disasters to help injuries. Field hospitals are somehow different in comparison with hospitals in terms of architectural plans, structures, and even applications. Mobile FHs are not equipped with permanent health facilities because they are established for emergency not daily illness. Furthermore, FHs consist of a set of internal and external parts, which are interconnected. When a disaster strikes, FHs are used to provide medical services in crisis or abnormal circumstances and emergency situations, reduce the number of victims and disabilities due to delay of providing medical services, prevent from occurrence of epidemic by providing diagnostic and medical services, and reduce costs and possible injuries (4, 7, 8). Field Hospitals can be employed after math of war as active auxiliary arms of the health system to provide health care in deprived and remote areas. When the number of victims and injuries are affected in certain areas, establishing a mobile FH is inevitable (9). Usually, a mobile FH in wars is made based on three principles of availability, health, and conditions of launching facilities such as water, electricity, and concealment (10). According to the importance of FH in saving injuries in crisis circumstances, as mentioned above, and since there is no comprehensive research that has reviewed these types of hospitals, the aim of this study was to present the latest information of hospitals in terms of structure, serviceability, placement, equipment, and other indices.

2. Objectives

In this research, field hospitals' structure and facilities erupted during the disasters were reviewed.

3. Methods

In the present study, a systematic review was performed following the PRISMA guidelines (Figure 1). To perform a systematic review study, all published papers before October 2017 that were indexed in MEDLINE, web of science, Google scholar, PubMed, Persian journals, and databases were searched. In addition, the keywords of

“field hospital”, “military hospital”, “mobile hospital”, “emergency medical unit”, “Medical relief”, “portable field hospitals” and “mobile health units” were used to search papers. Manual bibliographic review, internet searches, and expert consultation were conducted to ensure completeness of peer-reviewed studies. In the present study, all reported papers in types of review paper, systematic reviews and meta-analysis, qualitative and quantitative studies that were published in English or Persian languages with their full text available were selected. All found papers were evaluated by two reviewers to obtain the eligibility criteria for inclusion, while all the papers that did not fulfill all the eligibility criteria were not included. Eligibility criteria for review inclusion had to include the following:

- Require equipment for a field hospital
- Type of structure
- Plan or units of hospital
- Type of disaster like of war, earthquake, flood

4. Results

This research found 2921 papers at the screening step. At this step, the selection criteria were limited to title, while by more evaluation and abstract study, the selected publications were decreased to 175. At the eligibility step, 28 publications remained and finally 20 papers met the criteria and were included in the study. For extracted data included place, administrative organization, disaster type, year of occurrence, structure, equipment, and clinical team as the categorized themes (Tables 1 and 2). As Tables 1 and 2 show, structures used for establishing of a field hospital are usually tents, using vehicles (trucks and buses), pre-fabricated steel, and concrete structures, respectively. According to the present research results, the tent structures were the most common structures for the establishment of FHs when a disaster occurred.

The obtained results showed the war FH used in Korea, Vietnam, Iran, Kuwait, Iraq, Afghanistan, and Syria that were established by the US army, Iranian military force, British Military, Canadian forces, and Syrian American Medical society. On other hand, the military forces were the main organization that provided FH, especially during wars. The organization that provided FHs in natural disasters were IDF, Iranian military force, rescue teams (from U.S and Ukraine, France, British, Spain, and Norway), Turkish red crescent, Russian mobile hospital, Cuban medical team, and Chinese army forces.

5. Discussion

According to the Geneva convention during war, the parties involved in the war were prohibited to attack doc-

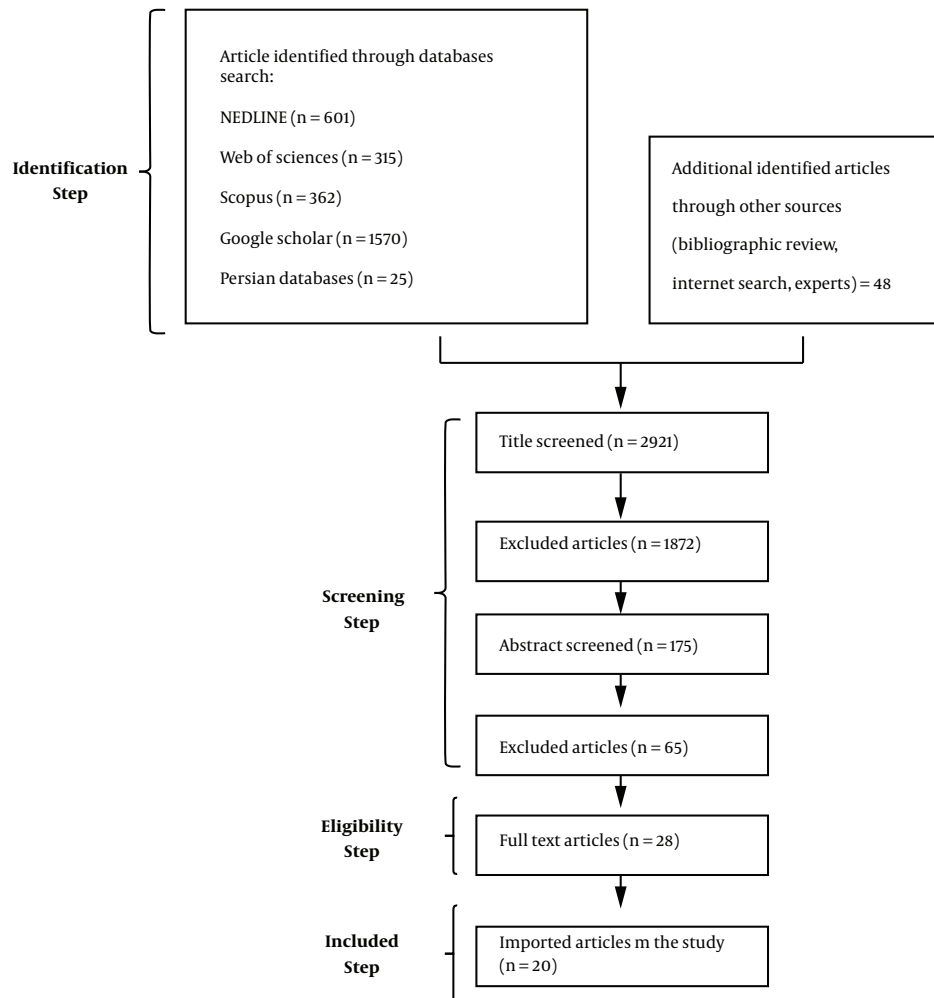


Figure 1. The used process to select articles among reviewed literatures

tors, ambulances, hospitals, and medical centers or places where FHs displayed a red cross or red crescent emblems, otherwise, war crimes occurred (1), yet unfortunately this takes place frequently during wars. According to the current study findings, although the tent structures were the most common structures for the establishment of FHs when a disaster occurred, yet based on disaster type, geography and the situation, it may be modified, improved or replaced by other structures. Conex and tents were the first structures used for field hospitals in Iran-Iraq war, yet after the Saddam regime attacked hospitals and medical centers, there was a need to increase the structure resistance against bomb and explosion. To reduce the casualties of the war, Iran had to change the structures of the hospital to steel and concrete structures and also used the principles of passive, defense such as camouflage, simultane-

ously. In the Syrian war, which was an asymmetric warfare, it was best to use local structures, such as schools, mosques, and so on as a field hospital structure (1). Selecting the type of structure (mobile and fixed) for hospitals clearly depends on the weather conditions, the environment, the type of disaster, the facilities available in the area, the extent and severity of the disaster, etc. Another example for selecting a suitable structure of FH is Syria. The civil war in this country will enter its eighth year. Meanwhile, more than 465,000 Syrians have been killed in the fighting and over a million are injured. In this situation, FH is necessary with special structure. Available reports show that in cities of Aleppo and Damascus, underground FHs are used to protect from bombs. Units of an FH have vital effects on FH efficiency. The results showed recent FHs have various units, while former FHs have no pro-

Table 1. Reported Field Hospitals Worldwide and Their Characteristics Based on Used Themes When War Was the Disaster

Place	Administrative Organization	Disaster Type / Year	Structure	Equipment	Clinical Team
Korea (5)	U.S army	War / 1950	MASH	-	-
Vietnam (5)	U.S army	War / 1966	MUST unit and 2nd MASH	Radiology, laboratory, pharmacy, dental, kitchen	-
Iran (6)	Iranian military force	War (Iran - Iraq) (1990 - 1998)	CONEX, tent, steel And concrete structure	-	-
Kuwait (5)	U.S army	The Gulf War / 1991	CSH and MASH and (DEPMEDS) or Tent	-	-
Iraq (10)	British military	War / 2003	Tent	Emergency department, a 4-bedded intensive, high dependency care unit, a 2-table operating theatre, 50 medium-dependency nursing beds, radiological services with X-ray, ultrasound and CT, basic pathology and laboratory services -A transfusion capability of packed, red cells and fresh frozen plasma was available.	general surgeon, orthopedic surgeon, consultant anesthetists, consultant in emergency medicine and, consultant physician supported by a small staff of junior doctors, nurses and paramedics.
Iraq (11)	U.S military	War / 2003	212th MASH	Emergency room, operating room tables.	General surgeons, thoracic surgeon, plastic surgeon, orthopedic surgeon, gynecologist, anesthesiologist, emergency medicine physician, internist, family practitioner, nursing staff from various disciplines.
Afghanistan (12)	Canadian, forces (CF) surgeons	War / 2006	Canadian combat hospital	Blood bank, ultrasonography, digital radiography, laboratory services, a CT scanner.	general surgeon, orthopedic, Surgeon, Anesthesiologists, Internist, Radiologist, oral surgeon, several family physicians.
Syria (13)	Doctors without borders (MSF), the Syrian American medical society (SAMS)	War / 2011	Syrian field hospitals were established. In hidden places like basements, farm houses, deserted buildings, mosques, churches, and factories.	Portable ventilator, cautery 400 watt, portable suction devise 90 L/M 2, Hot air sterilizer 85 L O ₂ generator machine, - portable X-ray device with accessories monitor defibrillator, pulse oximeter, abdominal surgical set, minor surgery set, orthopedic set, Ambu bag, laryngoscope, blood pressure device, stethoscope, Oxygen container, head light for surgery, generator, OR table, OR light, OR: operating.	Nurse, Surgeons, surgical assistant, anesthesiologist, surgeries to control peripheral or control abdominal surgeries, and burn care.

fessional staff and medical units. Generally, the establishment of a field hospital should include relief units, diagnostic treatment, emergency room, operating room, intensive care unit, radiology, pharmacy, laboratory and blood bank, sterilization department, special relief and transfer department, burn department and injured C.B.N. In general, the establishment of a field hospital should include relief units, diagnostic treatment, emergency room, operating room, intensive care units, radiology, pharmacy, laboratory and blood bank, sterilization department, special relief and transfer department, burn department and injured C.B.N, and regarding the clinical team, specialists in orthopedic and traumatology, plastic and reconstructive

surgery, infectious diseases, general surgery, anesthesia, pediatrics, internal medicine, and obstetrics and gynecology as well as orthopedic, anesthetic, radiology, and laboratory technicians, and nurses.

The results (Tables 1 and 2) illustrate that military forces, especially US army, is the most productive organization in FH establishment due to their experience in many disasters. It can be concluded that army forces of each country has an important role in success of FH, thus, collaboration with this organization can help with more success of FH. Table 3 presents the study findings compared with similar studies dealing with FH.

Table 3. The Comparison of the Present Study with Other Similar Studies

Article Type	Key Findings	Reference
Systematic review	The authors attempted to present and discuss suitable indicators to assess FHs performance. Finally, they concluded with 13 indicators to assess through literatures.	(4)
Clinical practice	The authors studied the development of mobile emergency (surgical) hospitals in China. A mobile emergency (surgical) hospital can be put in place where is need. It can provide emergency measures for patients or injured persons in disasters. The authors found that establishment of this type of hospital can treat a total of 1760 injured persons in Chengdu.	(5)
Brief report	There is a special situation in Syria because of military operations in high population density human settlement, as well as heavy conflicts between armed groups, thus the need for medical services person was very high while hospitals were unable to function. The existing situation and many of patients led to establishment of FHs in uncommon places, such as underground, farm houses, deserted buildings, mosques, churches, and factories. Underground FHs are an innovative and new system of FH to save patients and medical personnel from military operations, especially when fighting parties attacking patients and medical care staffs.	(9)
Original research article (reviewing available data)	The authors collected geographical data related to earthquakes to establish a suitable plane in FHs establishment and development of common structures after earthquakes. The authors concluded that the management team should have an early disaster response after earthquakes.	(11)
Original research article	The authors reviewed pediatric FH that were used to manage patients of Haiti earthquake in 2010. They evaluated equipment and medical staff requirements and plane of response to disaster. The study showed that in this situation, the medical records, medical care continuousness, contribution of experienced staff and decrease of staffs stress are most important and preferable in disaster management. The existence of a group of educated, experienced and volunteer team to dispatch to the FH in disasters can evolve the efficiency.	(21)
Original research article	The authors developed a maturity model called hospital Maturity Model (FHMM) in order to evaluate FH. By this evaluation method, FHs will be assessed by four themes including: a) FH structure and organization; b) existence guidelines and standards to establish a FH; c) the available methods of evaluation; d) the standards that are used to evaluate FH at national and international levels. The study concluded that by developing FHMM, the FH is evaluated well and efficiency of emergency medical care in disasters improves.	(22)
Original research article	The authors used multi-period mixed integer programming (MIP) to diminish the travel (time and number) of patients to medical care units. On other hand, they tried to develop a model to determine the location and required equipment for preparing an FH after each disaster. They showed this model can lower the cost of FH establishment and waiting time of patients to receive medical care, yet it needs to be calibrated by actual disasters.	(23)
Original research article	The author tried to discuss principles of FH and designs to use at each disaster type, based on the British Army experiences.	(24)
Systematic Review	In this systematic review study, field hospitals structure and facilities erupted during disasters were reviewed. The study reviewed available reports on FH to collect useful data that should be focused on establishment of an FH suitable a disaster. Furthermore, this study provided a list of the most important index that must be considered in proposing a type of FH. Tent structure was the most common structure for the establishment of FHs.	Present study

5.1. Conclusion

Identification of the HF type, equipment and structure are the first step to provide a FH. By using a suitable FH for a disaster, reduces risks by the FH. The present study reviewed available reports on FH to collect useful data that should be considered for an FH preparation. Furthermore, this study provided a list of the most important index that must be considered in proposing a type of FH. The main limitation of the present study was that only internet available reports on FH were included. As the nature of FHs some of cases may be unavailable to general especially FHs used by military forces it may be lost some of the applicable reports which were not available on internet.

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Footnotes

Competing Interests: The authors declare that they had no competing interests.

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Table 2. Reported Field Hospitals Worldwide and Their Characteristics Based on Used Themes in Case of Non-War or Natural Disasters

Place	Administrative Organization	Disaster Type / Year	Structure	Equipment	Clinical Team
Armenia (7)	Israel defense forces (IDF)	Earthquake / 1998	Sports hall	Triage and emergency department, internal medicine-adults, orthopedics, pediatrics, obstetrics and gynecology, operating theatre, recovery and intensive care, auxiliary services, radiology, laboratory, pharmacy, A logistic support unit included logistics, (i.e. supplies, kitchen, maintenance, communications, security), the command center.	Physicians, nurse, medics/paramedics, physical therapists, X-ray technics, lavatory technicians, pharmacists, management, nephrology, pediatrics, orthopedics, general surgery, urology, anesthesia, intensive care, neurology, psychiatry, internal medicine.
Turkey (7)	Israel defense forces (IDF)	Earthquake / 1999	Tent	Triage and emergency department, Internal medicine-adults, orthopedics, pediatrics, obstetrics and gynecology, operating theatre, recovery and intensive care, auxiliary services, radiology, laboratory, pharmacy, A logistic support unit included logistics, (i.e. supplies, kitchen, maintenance, communications, security), the command center.	Nurse, Medics/paramedics, X-ray technics, lavatory technicians, pharmacists, management, pediatrics, anesthesia, intensive care, neurology, internal medicine.
India (7)	Israel defense forces (IDF)	Earthquake / 2001	Fully self, sufficient tent encampment	Triage and emergency department, Internal medicine-adults, orthopedics, pediatrics, obstetrics and gynecology, operating theatre, recovery and intensive care, auxiliary services, radiology, laboratory, pharmacy, A logistic support unit included logistic, (i.e. supplies, kitchen, maintenance, communications, security), The command center.	-
Bam, Iran (1, 8, 9)	Iranian military force and rescue team from U.S, teams from the Ukraine, France, British, Spain, and Norway	Earthquake / 2003	Tent	-	Specialists in trauma surgery, obstetrics and gynecology, anesthesiology, primary care, Pediatrics, emergency medicine Physician assistants, emergency room, operating, room, and critical care, members of the team, as were paramedics, pharmacists, respiratory therapists, and logistics personnel.

Kashmir, Pakistan (14)	Turkish red crescent	Earthquake / 2005	Tent	Triage, dressing and patient, examination tent, outpatient tent, orthopedic intervention and plastering laboratory tent, roentgen, pharmacy tent, sterilization tent, - operation tents.	Physicians, orthopedic and traumatology specialists, one orthopedic and traumatology, nephrologist, pediatric specialist, obstetrics and gynecology specialist, infectious diseases specialist, otolaryngology specialist, radiologist, practitioners, anesthetic technicians, radiology technicians, laboratory technicians, orthopedic technician, nurses. The team was under the supervision of a senior orthopedic and traumatology specialist (MB).
Gulf coast region of Mississippi, U.S.A (12)	USA(state Medical assistance team)	Hurricane Katrina / 2005	Carolinas MED-1 mobile hospital and Tent	Emergency department, surgical suite, critical care beds, blood pressure monitoring, pulse oximetry, end-tidal capnometry, 3-lead and 12-lead electrocardiography, continuous ST-segment trend. Analysis: the capabilities of providing arterial, central venous pressure, Swan-Ganz catheter monitoring.	emergency physicians, trauma surgeon, orthopedic surgeon, anesthesiologist with augmentation, pediatrics, Family medicine.
Sumatra, Indonesia (15)	Russian mobile hospital	Earthquake / 2009	-	Modern medical equipment (X ray ultrasonic diagnostics etc.), Mobile CT, pneumo modules equipped pneumo modules with technical systems.	Engineers, surgeons, therapists, traumatologists, children's surgeons, pediatrician, anesthesiologists.
Chile (16)	Cuban medical team	Earthquake / 2010	Tent	A portable X-ray machine, ultrasound, four cardiovascular monitors, ventilators, anesthesia equipment, operating room, installation of indispensable air conditioning units.	Orthopedics, surgery, anesthesiology, family medicine, nurses, psychologist and support staff, general surgeons, orthopedic surgeons, anesthesiologists, Scrub nurses to cover positions in regional hospitals with facilities for more complex care but lacking qualified personnel.

Haiti (7, 17)	Israel defense forces Medical corps field hospital (IDF-MC)	Earthquake / 2010	Fully self-sufficient tent encampment	Triage and emergency department, Internal medicine-adults, orthopedics, pediatrics, obstetrics and gynecology, operating theatre, recovery and intensive care, auxiliary services, radiology, laboratory, pharmacy, A logistic support unit included logistics(i.e. supplies, kitchen, maintenance, communications, security), the command center.	Physicians, nurse, Medics/paramedics, X-ray technics, lavatory technicians, pharmacists, family medicine, pediatrics, orthopedics, general surgery, urology, anesthesia, intensive care, psychiatry, internal medicine, psychiatry.
Lushan, China (18)	Chinese army forces	Earthquake / 2013	Tent	Resuscitation and emergency surgery, first-aid materials, X-ray machine, ultrasonic instrument, a clinical laboratory, a mobile operating room.	Pediatricians, orthopedists, cerebral surgeons, anesthesiologists, thoracic surgeons, general surgeons, oral and maxillofacial surgeons, otolaryngologist, ophthalmologist, internists, pharmacist, clinical laboratory technician and nurses.
Bogo, Philippines (19)	Israel defense forces Medical corps field hospital(IDF-MC)	Typhoon Haiyan / 2013	Tent	Portable Otoscopes, foreign body loops, portable high-quality X-ray and ultrasound machines.	Radiologist, anesthesiologist, pediatricians, otolaryngologist, other healthcare personnel.
Nepal (20)	CISAR medical team	Earthquake / 2015	Tent	Emergency medicine, general surgery, gastroenterology, ultrasonic diagnosis, pharmacy, clinical, laboratory, nursing care.	-